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The biology of Great Green Macaw *Ara ambigua* in Southwest Ecuador

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Die Biologie des Großen Soldatenaras in Südwest-Ekuador

Untersucht wurde die Fortpflanzungsbiologie des Großen Soldatenaras *Ara ambigua* im Naturschutzgebiet Cerro Blanco im Südwesten Ekuadors. Tägliche Nestbeobachtungen brachten neue Erkenntnisse über die Ernährung der Vögel zutage, die zu 71% aus den Knollen von zwei Orchideen-Arten bestand. Als Nahrungskonkurrenten treten in diesem Gebiet nur der Feuerflügelsittich (*Brotogeris pyrrhopterus*) und das Guayaquilhörnchen (*Sciurus stramineus*) auf. Die Brutzeit der Aras liegt in der Trockenzeit (von Juli bis November). Die Studie vergleicht die aktuellen Ergebnisse mit den Daten aus dem Jahr 1994, die im selben Gebiet erfaßt wurden. Ein Brutpaar benötigt ein Areal von mindestens 2000 ha, um seinen Nahrungsbedarf zu decken. Die Großen Soldatenaras sind durch ihre Ortstreue und ihr brutbiologisches Verhalten von Veränderungen ihres Lebensraumes, des tropischen Trockenwalds, besonders gefährdet, so daß die wenigen, noch bestehenden Lebensräume dringend unter Schutz gestellt werden müssen und eine Wiederaufforstung mit heimischen Baumarten vonnöten ist. Nur dann sind Ekuadors Soldatenaras auf lange Sicht zu retten.

Schlagworte: Papageien, Soldatenara, *Ara ambigua*, Ekuador.

Summary

The reproductive ecology of the Great Green Macaw *Ara ambigua* was studied in the Bosque Protector Cerro Blanco and adjacent areas situated in southwest Ecuador. Between 10 July 1997-30 June 1998 the species was monitored over an area of c. 4,500 ha. discovering one nest. Daily nest observations provided new information on the species' diet. From 26 July-19 November 1997, the consumption of two orchid spp. formed 71% of the species' diet. The only other registered competitors that feed on the same diet as *Ara ambigua* are Grey-cheeked Parakeet *Brotogeris pyrrhopterus* and Guayaquil Squirrel *Sciurus stramineus*. The reproductive period extends from 10 July-11 November 1997 (dry season). The study compared and analyzed information from a nest in 1994 from the same study area. The species conduct of parental care was reflective of the known behaviour of the species and the genus. We established the movement patterns of the pair and determined that a minimum c. 2,000 ha. foraging area is required. We registered the seizure of the study nest by a pair of Collared Forest-falcon *Micrastur semitorquatus*. The sedentary nature of this species and its reproductive habits make it considerably vulnerable to physical or ecological disturbance of tropical dry forest. Protection of current conservation areas, reforestation with native species, and the acquisition of private

forested areas so that the population is concentrated in protected areas, will help safeguard the species long-term survival in the region.

Keywords: Parrots, Great Green Macaw, *Ara ambigua*, Ecuador.

1 Introduction

The population of Great Green Macaw *Ara ambigua* in Ecuador presents serious problems for conservation, owing to natural habitat loss, human persecution and cage bird trade (CHAPMAN 1926, FORSHAW 1977, KING 1981, RIDGELY 1981, ABRAMSON 1986, FJELDSÅ et al. 1987, PARKER & CARR 1992, TORAL 1992, BERG 1994, COLLAR et al. 1994, LOW 1994, 1995 and 1997, WAUGH 1995, BERG & HORSTMAN 1996, COLLAR 1996, HORSTMAN 1996b, STOTZ 1996, ANONYMUS 1997, COLLAR 1997, GRANIZO et al. 1997, PFEFFER 1997, POPLE et al. 1997a, 1997b, and JUNIPER & PARR 1998). In Ecuador, the species is considered Threatened owing to severe population fragmentation, with less than ten locations remaining (GRANIZO et al. 1997). At the global level, *Ara ambigua* is treated as threatened with extinction in Appendix I of CITES and was considered Vulnerable when treated as conspecific with Military Macaw *Ara militaris* (COLLAR et al. 1994). The species is represented by less than 100 individuals in NW Ecuador (TORAL 1992, R. S. RIDGELY in WAUGH 1995, R. S. RIDGELY in LOW 1995, JUNIPER & PARR 1998) and few records in the rest of its distribution in the south, thus prompting urgent conservation action.

The few ecological studies conducted throughout the species distributional range have emphasized the vital need for detailed ecological and population field studies of *Ara ambigua* to understand its requirements for long-term survival in the region. This study provided new knowledge to the species natural history.

2 Study site

The study was undertaken in Bosque Protector Cerro Blanco (BPCB), Guayas, Ecuador (2°10' S, 80°02' W), and adjacent areas in the north of the reserve. The site covers c. 4,500 ha. from c. 12–400 m elevation. The terrain is mountainous with level peaks, streams and valleys on the periphery of BPCB. The annual climate cycle is a wet winter season between December and March, and a dry summer season the rest of the year. In the summer period, the majority of the vegetation in the valleys, slopes and hillslides of the Cerro sheds its leaves, with the exception of areas along streams where vegetation is evergreen. All foliage returns in the winter months. The study site is situated in the extreme east of the Cordillera Costera Chongón-Colonche, c. 10 km NE of Guayaquil city. Its physiognomy corresponds to the Tumbesian region with Tropical Dry Forest (PARKER & CARR 1995, BEST & KESSLER 1995), with BPCB containing 3,500 ha. The vegetation consists of deciduous dry forest, with evergreen sec-

tors along stream valleys. The northern limit of BPCB, estimated to be c. 1,000 ha, contains large valleys with hills to 300 m elevation. The area pertains to cooperatives and rural farms. The vegetation is composed of secondary forest with predominately „Pigío" *Cavanillesia platanifolia* (Bombacaceae) and „Amarillo" *Centrolobium ochroxylum* (Fabaceae). The principal trees and bushes of the study area include: Bombacaceae, Fabaceae, Cecropiaceae, Verbenaceae, and Bignonaceae.

3 Methods and Materials

The species was studied for one year from July 1997 to June 1998. The study commenced with consecutive five-day surveys of 12 hours per day to encounter the species and find active nesting sites. An extensive network of trails was used in the reserve as well as various high elevation viewpoints selected from maps. For the nesting site, 12 hour per day observation periods were conducted until the nest was abandoned. By the end, we had established two quadrats measuring c. 60 and 200 m respectively. In the smaller quadrat only nest observations were undertaken, whilst general observation on the species movements were undertaken in the large quadrat. It was possible to sex individuals of the breeding pair following copulation observations, with differences in the body dimensions and measurements, bill coloration, and plumage marks. The nest was not checked to avoid any alteration of the behaviour by the pair and/or young. To follow the species over the study area, a combination of strategic points and viewpoints were used to monitor the species movements. Viewpoints were selected on elevation high-points over-looking valleys situated in the north of BPCB. Strategic points were situated near the position of forest-guard stations, covering other areas of the reserve to locate and observe the species over large areas of the reserve. Viewpoints were visited once a week, whilst strategic points were monitored throughout daylight hours – 12 hours daily. One person was required to undertake the surveys and an additional person needed to monitor each nest. Binoculars (x10), telescope (x20), sound-recording gear (Sony TCM-5000EV), microphone (Sennheiser ME-88), and photographic camera and lens (28–50, 300, 600 and 1,000 mm) were used. Sound recordings were made of various vocalisations that varied according to the birds behaviour. To estimate the foraging range and territory of the breeding pair in 1997, geographical maps from Instituto Geográfico Militar de Ecuador (IGM, scale 1:50.000) and a GPS system were used. This permitted the approximate range (ha.) used by the breeding pair to be calculated, and thus provide an estimate of the minimum population at the study site.

When fieldwork was completed we analyzed a volume of past and present nesting data and wildlife observation sheets that the reserve administration had obtained from visitors, staff and forest guards from 1995. These observation sheets registered each species observation: day, number of individuals, behaviour and general comments. Landowners and workers in adjacent areas of the reserve limits were interviewed in the hope of gaining anecdotal information about the species. Afterwards, to compare records, we visited the largest remnant secondary forest patches outside of the reserve.

The analysis of nesting observations was undertaken in the form of a table with time and behaviour variables. Graphics were made up of selected variables of behaviour in relation to one-minute units of time. We compared the absence of the parents in the nest of 1994 and 1997 during the same time period, taking as references the temporal abandoning of nestlings at the same point. In the preparation of the diet table we compiled all known information, but separated the reliable from the anecdotal information. Information on the diet was obtained through the collection of items below trees the species foraged in, and/or by climbing trees using tree ascending equipment to get samples. We attempted to collect 20 samples for each type of food. All food samples collected were measured and results presented in a table. For the bark analysis of *C. platanifolia* a laboratory physiochemical analysis using standard methods, including pH (Orion pH meter); Thermocuple at 25°C; protein measurements using the Kjeldahl method; fats released during acidification of pH5; dry weight after stove heating to 500°C over two hours; and hydrocarbons measurements following techniques given in A.O.A.C. This physiochemical analysis obtained considers the difference between the organic, biochemical compounds and energy differences between samples. Metals were determined by spectrometer readings and using other standard procedures for Cd, As, Cu, As, Na and K.

4 Results

2,941 man-hours were spent in the field over an area of about 4,500 ha., totaling 159 days of study between 10 July 1997 and 30 June 1998. During the monitoring of the nest from 10 July to 5 December 1997, 2,820 man-hours were spent in the field totaling 144 days of study.

4.1 Reproductive Biology

A nest was discovered on 14 July 1997, apparently at the start of the incubation period. The chick first left the nest after c. 4 months on 11 November. By comparison, the nest encountered in 1994 was found with chicks on 14 August and abandoned by the last chick on 1 October (WAUGH 1995, BERG & HORSTMAN 1996). Calculating that the period of incubation and the development of the chicks is approximately four months (ABRAMSON in BJORK & POWELL 1995, LOW 1995, COLLAR 1997, the author, pers. obs.), the incubation period of the 1994 nest could have started at the beginning of June. Considering both cases, the breeding season in the region could be between June and November, in the dry season. The location of the 1997 nest (02°07'54" S and 80°04'31" W) was outside the limits of the BPCB. Its surroundings consisted of forest scattered with *C. platanifolia*, and secondary growth, in a valley with a number of gullies. The nest cavity was 20 m above the ground in a lone *C. platanifolia* with the following trunk diameters: 2 m at breast height, and 90 cm at the height of the nest hole. The bark of the main trunk was green but the inner part of the upper section showed

signs of decay. The nest hole was located in the upper part (top of tree), open and exposed to the elements. At the start of the nest observations of study, the cavity was partially hidden by branches, twigs and leaves. The latter of which were gradually shed with the advent of the dry season until the nest hole was totally exposed. The *C. platanifolia* where the nest was located was isolated from other trees in the lower reaches of one of the gullies.

Pair of Green Great Macaw Ara ambigua *at nest entrance on Pigío (Cavanillesia platanifolia). – Paar des Großen Soldatenaras am Nesteingang .*

On 13 July 1997, the pair was observed foraging far from the nest (about 600 metres). From 14 July, the female was never seen far from the nest, until 4 September (52 days later), when the chick was somewhat more developed. The only occasions on which the female left the nest together with the male was to receive food for regurgitation three or four times a day, for a period of two to six minutes, when she never went more than about 60 metres from the nest. During those sorties the female normally complemented her diet by eating two to four orchid bulbs. The male left two or three times a day to find food, for a time span of two to three hours. Depending on the amount of food collected and the distance covered to the feeding areas, the periods of absence

lasted between 20 and 180 minutes. This sequence lasted from 14 July to 4 September, when the female began to accompany the male for prolonged periods of up to 180 minutes in order to feed for herself. The increase in absence of the pair from the nest or its immediate surroundings is illustrated in figures 1 and 2. It seems that this behaviour was related to the growth of the chick allowing it to remain unattended for longer periods. On 12 October, the chick was mobbed and attacked by a Collared Forest-Falcon *Micrastur semitorquatus* whilst its parents were absent, but was able to defend itself from being taken as prey. Figure 2 indicates a greater absence of the parents from the 1994 nest than that found in 1997. Figure 1 shows a direct link between the absence of the pair of macaws and the absence of birds of prey from the area of the nest. When the presence of raptors was more significant, the pair was noted to spend more time around the nest in order to protect the chick. In the second half of October there were days of up to ten attacks by *M. semitorquatus*, when the parents did not leave the nest at all during the day (Fig. 2). In these instances, it seemed that the pair did not consume any kind of food until the following day. During the most intense attacks, and the constant presence of the pair at the nest, the male was seen on a couple of occasions regurgitating food for the chick, apparently without having gone out to find food since the previous day.

On 20 September 1997, observations began regarding the cleaning of the nest hole. This behaviour consisted of clearing the floor of the nest with bill and feet, and removing the debris out of the nest, by ejecting it behind and below the body using the feet. This behaviour could in consequence be observed on a daily basis until the period of observation of the nest came to an end. Cleaning the nest was the duty of both sexes. It was not possible to determine from the parent's behaviour the day of the hatching of the egg. The feeding of the chick was performed within the nest hole cavity, seemingly only by the female during an initial period. On 15 November, the male began to feed the chick. The only recorded offspring began to be heard from inside the nest on 27 August. There was no superposition in vocalisations in the absence of the adults from the nest, indicating that from that date, there was only one chick. On 14 October, the chick was detected flapping its wings for the first time, within the nest. These exercises could be observed more frequently from this date. On 31 October, the chick was seen poking its head out of the hole for the first time. On 6 November, the *M. semitorquatus* prevented the pair from returning to the nest, by attacking them and repelling them every time they came near. The pair continued feeding with normal periods of absence. On returning they tried to enter the nest but were unsuccessful. On some occasions the pair was pursued by the *M. semitorquatus* to about 200 metres away from the nest. On two days the chick was not fed at all (at least during the day) and the pair could be heard calling nearby. During this time the chick was attacked twenty times. On 8 November it was ejected from the nest and fell to the ground. It was subsequently rescued to ensure its survival, and reunited with its parents five days later (13 November) when it could fly. The *M. semitorquatus* did not abandon the nest they had seized, and occupied the cavity themselves to nest (LÓPEZ-LANÚS, in prep.). Despite the loss of the chick, the parents did not leave the area, repeatedly visiting the area around the nest until at least 10 December. TORAL (1992) described this behaviour in the nests of *Ara ambigua* created artificially by pet traders.

4.2 Tracking the chick and its relationship with its parents

From 14 November 1997 it was observed that the chick was left behind when it flew together with its parents. On several occasions it tended not to follow the route indicated by the pair and the adult birds had to turn back in a circle to reach it, and guide it again in the direction in which they were flying. In this situation, both the young bird and the parents were generally more vocal than usual. During the first week, the chick was clumsy when landing, often colliding with the branches of *C. platanifolia*. During the first two weeks, the couple fed in the area and remained close to the young bird,

Semi-evergreen Pigío forest, habitat of Green Great Macaw in Ecuador.
– Halbimmergrüner Pigío-Wald, Lebensraum des Großen Soldatenaras in Ekuador.

which was fed by regurgitation on the branches of *C. platanifolia*. Thereafter the chick remained alone in the area for up to five hours while the pair left the area to look for food. No attacks of any kind on either the chick or the adults were noted after the nest had been abandoned. While waiting for its parents, the young bird changed trees but always remained in the area of the nest. The adults apparently located the young bird vocally. In this case, the parents exchanged calls with the chick from a distance of 500 metres until they were reunited. During the days when the chick was in the rescue centre, the adults spent the night at a roosting site on a branch of a *C. platanifolia*, located about 200 metres from the nest. On both occasions they occupied the same place on thin branches near the tree crown. The adults had another roosting site over 700 metres from the nest but it could not be monitored. The young bird was able to follow the adults to the roost described, but it did not sleep with or near them, but about 40 metres away in another tree of the same species. In contrast to the adults, for its roosting

site the young bird chose branches that were thicker, more varied in colour and nearer the centre of the tree crown. Following this observation no other roosting sites were located. Nevertheless, it was discovered that both the adults and the chick did spend the night in the area, very probably in other *C. platanifolia*. On certain occasions the pair spent the night more than 400 metres away from the chick.

During the first week of the reintegration of adults and offspring, the young bird was seen chewing the stalks and bulbs of orchids without ingesting them. On occasions when the adult birds were consuming orchids, the chick did not approach them except to demand food. The chick was fed by regurgitation in the same way until at least 1 December. The pair was never observed approaching the chick apart from to feed it. The chick preened itself without assistance from its parents. From the second week, the chick began to move to increasingly distant trees with greater regularity. Accordingly, observations became more and more sporadic as the pair left together with the young bird for up to two or three days at a time. The whereabouts of the three individuals during these periods of absence is unknown, except that they left to, and returned from, the west, outside the BPCB. On one occasion when they returned to the area the adults and the chick were seen near the nest. The adult birds tried to inspect it but found it still occupied by the pair of *M. semitorquatus*, which drove them away.

4.3 Analysis of the 1994 nest

The 1994 nest was monitored daily from 14 August to 1 October (WAUGH 1995, BERG & HORSTMAN 1996b). The analysis of the data collected during this time, which until now has not been processed, is presented in this report for comparison. This pair was usually away three times a day to feed and returned with food for the chick. In general, the first sortie of the morning occurred about 30–45 minutes after dawn (n = 42 days). After about 20–30 minutes the pair returned to feed the chicks, leaving again a few hours later. In the afternoon they generally made another prolonged sortie. Fig. 2 shows the number of minutes of absence per day from the nest during the period of study of the nest in 1994 in comparison with 1997. The same graph shows how eight days before the chicks left the nest, the absences of the adult birds were longer than normal. On average the chicks were fed three times a day (n = 42 days). Twenty-six days before the last chick was to leave the nest, the cleaning of the nest hole cavity was observed as described for the 1997 nest. From then on this behaviour was recorded daily or every other day. The first chick appeared at the nest hole 29 days before the last one left the nest. Seven days before they left the nest the adults slept away from the area, returning the following day at first light to continue the feeding process as described. From then on the pair did not return to the nest to sleep until the chicks had vacated it. The chicks began to practice flying outside the nest hole seven days before they left. The chicks flew for the first time during the first hour of the day, in the presence of the adult birds. The first flight of the two chicks was two days apart. In each case the first flight was decisive, prolonged and steady, following the adult birds away from the area where the nest was located. The first chick did not return to

the area following its departure, while the parents returned during the following two days to feed the chick that had not yet learned to fly.

On 7 and 8 October 1994, LÓPEZ et al. (1994) observed the juveniles with the adult birds in the area around the nest. From then until December they did not encounter either the adults or the young in the area. There were various sightings of the four birds during December 1994 outside the BPCB in areas adjacent to the area of the nest and in the Represa Chongón-Colonche (it is highly improbable that these sightings were of different individuals). Neither the chicks nor the adults were recorded returning to the nest to spend the night.

4.4 Diet, foraging habits and competition for food

The provisional list of food items consumed by the species in the study area is shown in Table 1. The table divides food consumed as proven by direct observation by the author, and those classed as hypothetical based on anecdotal information.

Tab. 1: Diet of *Ara ambigua* in the Bosque Protector Cerro Blanco and adjacent areas. – Nahrungspflanzen von *Ara ambigua* im Bosque Protector Cerro Blanco und den angrenzenden Gebieten.

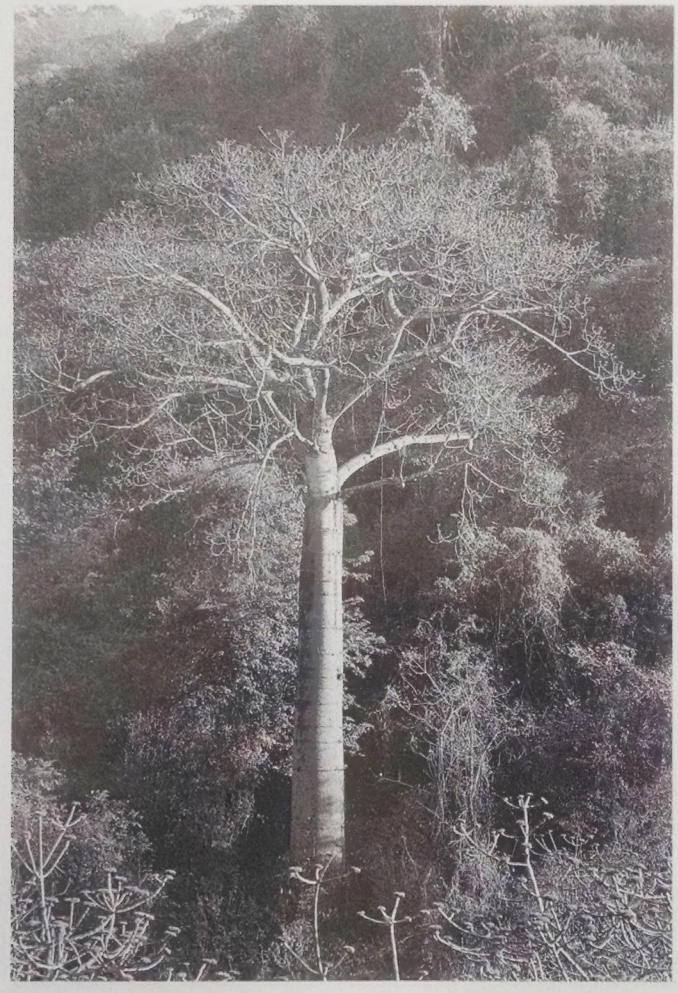
Local name	Scientific name	Family	Parts
Pigío	*Cavanillesia platanifolia*	Bombacaceae	Flower, seed, bark (+ dust)
Balsa	*Odroma pyramidalis*	Bombacaceae	Seed
Beldaco	*Pseudobombax guayasense*	Bombacaceae	Seed
Pechiche	*Vitex gigantea*	Verbenaceae	Fruit (whole?)
Bototillo	*Cochlospermum vitifolium*	Cochlospermaceae	Seed
Amarillo	*Centrolobium ochroxylum*	Fabaceae	Seed
Guarumo	*Cecropia litoralis*	Cecropiaceae	Inflorescence
(?)	*Ipomea sp.*	Convolvulaceae	Seed
Orquídea	*Epidendrum collare*	Orchidaceae	Bulb
Orquídea	*Encyclia aspera*	Orchidaceae	Bulb, root

Note: water contained in *Tillandsia* sp.

Records of species according to anecdotal information

Local name	Scientific name	Family	Parts
Cocobolo	*Cynometra bauhiniifolia*	Fabaceae	Seed
Modroño (?)	(?)	(?)	Seed

The collection of data was very detailed in the area close to the 1997 nest, in contrast to other foraging zones where the birds could not be followed. The diet and the true daily percentages of ingestion inevitably differed from the analysis of data obtained, due to the impossibility of observing the individuals on a permanent basis when feeding. Nevertheless, the table 2 show the tendency of food preferences. The order of preferences for feeding between 26 July and 19 November 1997 are indicated in table 2a-d The consumption of flowers, bark and seeds of *C. platanifolia* (11.8%) was grea-



The Pigío tree (Cavanillesia platanifolia), – Der Pigio-Baum.

ter than seeds of *C. ochroxylum* (9.7%). However, the consumption of seeds of *C. platanifolia* (8.6%) was less than that of the seeds of *C. ochroxylum* (9.7%). The percentages in the foraging for seeds between both species are inverted during October and November (Table 2d), with the seeds of *C. platanifolia* (20%) consumed more than those of *C. ochroxylum* (2%). The consumption of orchid bulbs, bark of *C. platanifolia* and seeds of *C. ochroxylum* was regular during the period indicated (Table 2a-d).

The consumption of orchids was common during observations made of the 1997 nest. The two species of orchids consumed were both common in the area. They were

essentially located in the branches of *C. platanifolia*, about 15 to 20 metres off the ground, and therefore easily accessible for the macaws. The two species of orchid were also recorded together in the same tree. The macaws walked along the branch searching out the bulbs, which they often chose by biting into them to check that they were in good condition to eat; bulbs that were dehydrated or dead were discarded. The bulbs of the two orchid species were succulent, and in the case of *E. collare*, developed up to 30 cm. The consumption of the bulbs lasted between ten seconds and five minutes ingesting, up to four per minute maximum. They would either consume several bulbs from the same plant or go searching from plant to plant. The greatest consumption of bulbs occurred in those with a tendency to dry out on the outside. On one occasion the consumption of the roots of an orchid was observed in an E. aspera. In the area there were two more species of orchid (*Catleya maxima* and *Oncidium planitable*) which were not recorded as forming part of the bird's diet. These were not particularly succulent, and were rather scarce in the study area.

The fruits of *C. ochroxylum* were consumed during the entire study period of the 1997 nest (Table 2a-d), with an apparent tendency towards ingestion immediately after heavy rain. During October and November (Table 2d) consumption decreased to 2%. Due to the nature of the fruit the seeds were not easy to reach, and on one occasion an individual spent 20 minutes opening a fruit to consume the seed. The majority of the fruits were not in prime condition for consumption during the period described and were discarded on inspection. With the increase in precipitation from the second half of September, the intake of water became more evident (Table 2b-d). Immediately after significant downpours the birds visited certain *C. platanifolia* containing *Tillandsia* sp. These retained water at the base of their leaves. On several occasions (n = 6) the intake of water coincided with a period foraging in *C. ochroxylum*. To drink they inserted their beaks between the leaves. In some instances they were able partially to dismantle the leaf. On one occasion one individual chewed a saturated leaf which it did not then eat, seemingly purely to obtain water.

The period when *C. platanifolia* was in flower in the areas close to the nest studied in 1997 was largely in September (the author, pers. obs.). The consumption of flowers consisted of extracting the petals, chewing them and then discarding them. Table 2a-d shows the period of consumption of flowers in relation to the remainder of the diet during the study of the nest in 1997. An overlap in the consumption of flowers and seeds was noted due to the different times of flowering of different plants of *C. platanifolia*. The consumption of seeds increased considerably in accordance with the existing quantity on offer. The maximum period of consumption of seeds was about 25 minutes. LÓPEZ et al. (1994) and LÓPEZ-LANÚS (1996) recorded the consumption of seeds of *C. platanifolia* during September and October, respectively. The ingestion of bark and dust in the bark was only observed in *C. platanifolia*. Table 2a-d show the regularity of their consumption during the entire period indicated. On two occasions an individual was seen extracting and chewing pieces of bark of about 3 cm wide by 40 cm long. More observations were made of birds consuming dust in the bark. They obtained the dust by means of scraping the bark with their mandibles like a spade, and using the tip of their maxilla like a crowbar. The maximum period of the consumption

of bark or of dust in the bark was about two minutes. There was preference for obtaining powdered bark in the parts of the branches where there were black markings (fungi?). Analysis of the bark of *C. platanifolia* revealed the following data: chemical analysis: pH 5.11, proteins 6.54%, fats 0.14%, ashes 8.96%, and hydrocarbons 82.36%. Traces of metal (in ppm) : iron 168.22, potassium 3669.16 and calcium 3669.16.

Nesting site of Ara ambigua *in Southwest Ecuador.*
– Nistplatz des Großen Soldatenaras in Südwest-Ekuador.

The ingestion of *Ipomea* sp. was only observed during the monitoring of the 1997 nest. Its consumption was recorded from 5 September onwards. The seeds were extracted with ease by opening the thin outer layer of a fruit with four seeds separated by thin partitions and covered by a transparent membrane. The maximum period of consumption was about 13 minutes. On two occasions the male was seen regurgitating what seemed to be an entire seed of this species. On one sole occasion the species was recorded foraging on inflorescences of *Cecropia litoralis* (J. REYES & P. YAGUAL, pers. comm.). *C. litoralis* was not recorded in the valley where the nest was monitored in 1997. This observation was made near a stream and in a deforested area that was recovering, where the species was common. On one occasion the birds were seen feeding on seeds of *Cyanometra bauhiniifolia* (J. REYES pers. comm.). They were also recorded feeding on a climbing plant known locally as *modroño* (P. YAGUAL, pers. comm.). The fruits of *Vitex gigantea* form an important part of the diet (HORSTMAN 1996b, LÓPEZ-LANÚS 1996). LÓPEZ-LANÚS (1996) recorded the birds feeding on this species in the same tree for three days in November 1996. The maximum period of ingestion of fruit was of one-and-a-half hours. LÓPEZ-LANÚS (1996) recorded the consumption of seeds of *Cochlospernum vitifoliumand Odroma pyramidalis*. The observation of

consumption of seeds of *C. vitifolium* was made by LÓPEZ-LANÚS (1996) in November 1996. Its ingestion was of a seed previously separated from its „wool". The maximum period of feeding was three minutes. The consumption of *Pseudobombax guayasense* was recorded during the monitoring of the nest in 1994 and by LÓPEZ et al. (1994).

All observations of feeding indicate that the species tended to exhaust the food supply in one particular place. The nesting pairs in 1994 and 1997 showed a tendency to change their foraging areas every three or four days. This behaviour is reflected in the different directions that the pair took on leaving the nest in 1994 and in 1997, indicating changes in the feeding sites.

Table 2: Food ingestion by percentage (according to the indicated period). – Nahrungsaufnahme in Prozent (in Abhängigkeit von der Jahreszeit).

Periods	26/7–19/11	a 26/7 – 15/8	b 16/8–15/9	c 16/9–15/10	d 16/10–19/11
Epidendrum collare	20	15.4%	9%	27%	31%
Encyclia aspera	15.7	– (*)	9%	25%	13%
Centrolobium ochroxylum	9.8	21.5%	3%	13%	2%
C. platanifolia flowers	0.5	–	1%	–	–
C. platanifolia bark	1.7	0.3%	2%	2%	–
C. platanifolia seeds	8.6	–	–	14%	20%
Ipomea sp.	1.9	–	5%	–	–
Water	5.2	0.9	–	9%	7%
Orchids without identification	36.3	61.9	71%	9%	27%
Cecropia litoralis	0.3	–	–	1%	–

(*) see „Orchids without identification"

4.5 Competition for food

The only examples where competitors have been seen feeding on the same diet as the macaws are *C. platanifolia* and *P. guayasense*. When *C. platanifolia* was in flower, Grey-cheeked Parakeet *Brotogeris pyrrhopterus* was seen feeding on flowers of this species in groups of up to 12 individuals, occasionally even on the same group of flowers on which the macaws had previously been feeding. When the tree was in fruit, *B. pyrrhopterus* and Guayaquil Squirrel *Sciurus stramineus* fed on its seeds. No form of aggression was recorded between the macaws and *B. pyrrhopterus*, although the two were never recorded together in the same tree. Before the flowering of this tree species, a *Sciurus* sp. chased the pair of macaws which was eating orchids, running along the branches and successfully scaring them away. Whilst there were no seeds, at that stage the *Sciurus* sp. was a competitor. On no occasion was a *Sciurus* sp. seen feeding on orchids. Subsequently, during times when the trees were in fruit, both species were found together feeding in the same tree, occasionally on the same branch,

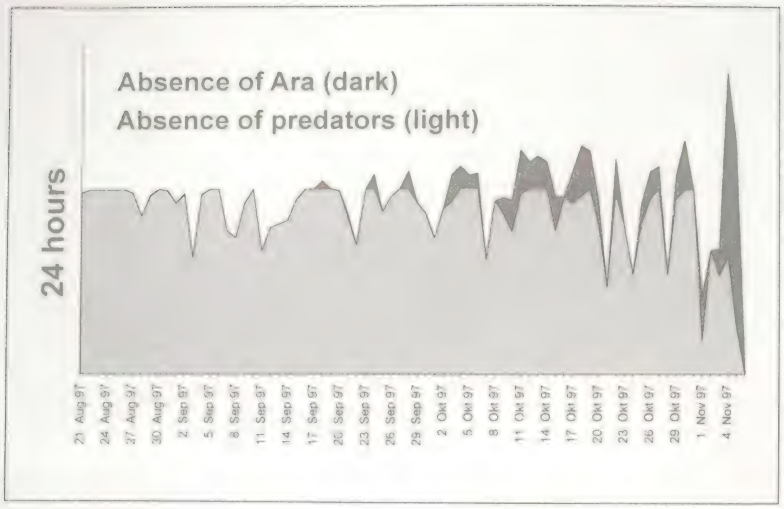


Fig. 1:

Predators' and/or Ara ambigua*'s periods of absence in the 1997 nest.*
– Zeiträume, in denen die Freßfeinde und/oder die Soldatenaras abwesend waren (1997 Nest).

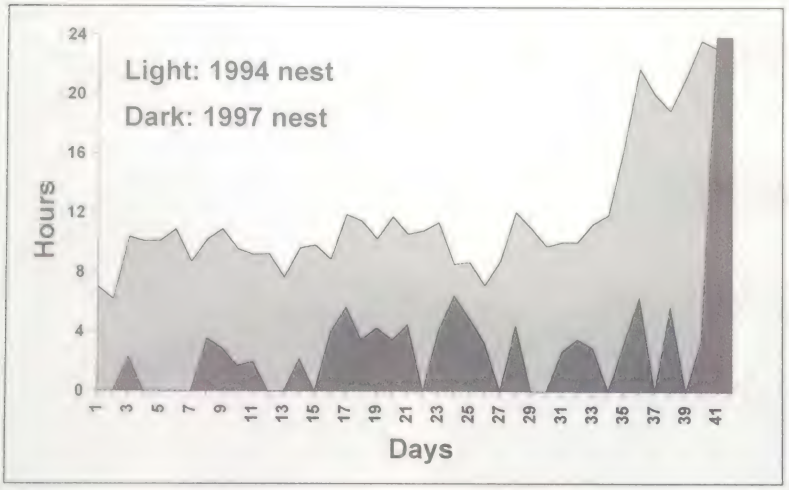


Fig. 2:

Ara ambigua*'s periods of absence in the 1994 and 1997 nests. There are compared equal periods of time previous to the juveniles' nest abandon.*
– Vergleich der Abwesenheitszeiten (1994 und 1997) vom Nest beim Großen Soldatenara.

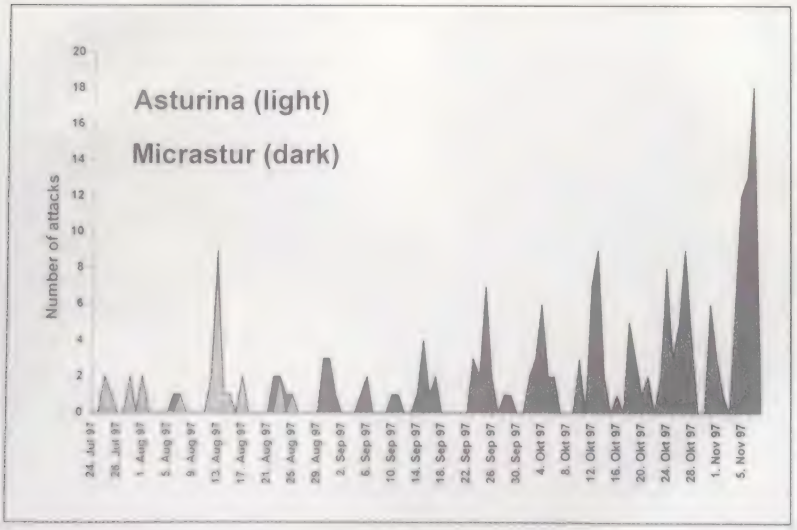


Fig. 3:

Asturina nitida *and* Micrastur semitorquatus*'s attacks to the* Ara ambigua*'s nest of 1997.*
– Angriffe von Greifvögeln auf das 1997er Nest des Großen Soldatenaras.

without the *Sciurus* sp. always reacting aggressively. The macaws were never seen driving away the *Sciurus* sp. In October 1996 (LÓPEZ-LANÚS, pers. obs.) a flock of *B. pyrrhopterus* was recorded feeding on the fruits of *P. guayasense*.

As regards the other Psittacidae present in the area, Pacific Parrotlet *Forpus coelestis*, Bronze-winged Parrot *Pionus chalcopterus* and Red-fronted Amazon *Amazona autumnalis* have never been seen feeding on the same diet as the study species. Similarly, KUNZ (1995) did not record in the diet of *A. autumnalis* any of the foods consumed by the macaws.

4.6 Presence of potential predators

During the period of study, the species was attacked by Grey-lined Hawk *Asturina nitida*, *M. semitorquatus* and an unidentified falcon (*Falco* sp.). The only species that were observed striking and/or seizing hold of the macaws were *A. nitida* and *M. semitorquatus*. From 10 July until 23 August 1997, a pair of *A. nitida* had an active nest 40 metres from the macaws' nest, which was constructed in a mature *C. platanifolia*. On many occasions the individuals passed near the macaw nest to leave or return to the area. On these occasions, the macaws became alarmed and adopted defensive postures. Nevertheless, these situations were not considered attacks except when they were clearly intentional, such as when an individual dived down to strike or pass within a few centimetres of the male macaw. These attacks increased in frequency as shown in Fig. 3. The attacks took place only when the male was present, and were not recorded on occasions when only the female or the eggs were in the nest. The attacks did not become more common when it became clear that the pair had chicks. The attacks decreased in frequency when the hawk nest was predated on 23 August for unknown reasons.

From 14 July 1997 a pair of *M. semitorquatus* was discovered stalking the nest. From that date on, the individuals present were apparently always those that remained in the area until they stole the macaw nest (LÓPEZ-LANÚS in prep.). On 6 August 1997, a female *M. semitorquatus* entered the nest hole and left 15 seconds later when one of the macaws returned to protect the nest. It could not be confirmed if part of the clutch of eggs was damaged. From the end of August the attacks became more frequent (Fig. 3). They consisted of direct fly-bys at great speed just a few centimetres from the macaws, blows, fights in mid-air pecking and seizing hold of each other before letting go near the ground, and/or chases in flight.

On one occasion the *Falco* sp. attacked the adult birds with a low fly-by when they were in a clump of *C. platanifolia* 150 metres from the nest. On 29 August 1997, the pair took up a position of defence in the nest in the presence of two Turkey Vultures *Cathartes aura*. When the macaws were absent from the nest, the vultures flew around it several times and on one occasion, a short distance away from it, when they were perhaps able to make out the presence of the chick. One individual tried to land on the

nest, but pulled up one metre before doing so. In the 1994 nest, *C. aura* was driven away by the pair of macaws on a couple of occasions, but a pair of vultures did once land on that nest in the absence of the adult macaws, and preened themselves at a distance of about 50 cm from the entrance and where the chicks were. Spectacled Owl *Pulsatrix perspicillata* was never observed near the nest despite its abundance in the area (three pairs per 500 ha). TORAL (1992) cited *P. perspicillata* as a potential predator according to anecdotal information.

4.7 Foraging area

The minimum foraging area of the pair with the nest in 1997 was estimated at about c. 2,000 ha. The exact area is unknown due to the fact that it was not possible to follow the male or the pair during their more prolonged absences. In 118 days of observation of the nest on only two occasions was the presence of different individuals of the same species confirmed in the area. These observations were either direct or deduced through the overlap of times and dates of different records. On one occasion the study pair allowed the approach of a visiting pair which arrived in the area of the nest from the north. By means of contact calls the visiting pair approached to 50 metres from the nest, but there was only minimal contact with the resident pair, which emerged on the arrival of the visitors. Fifteen minutes later the resident pair began to drive the intruders away, briefly pursuing them on short flights. There was no direct physical aggression. The visiting pair set off to the west without landing, until they disappeared from view. On a second occasion, contact calls were heard between the study pair and at least one visiting individual that did not approach the area of the nest. In this instance the study pair showed no sign of aggression. This visiting pair could be the same one that was seen regularly on the property called „El Molino de Casas Viejas" (trad: The Windmill of Old Houses), about 5 km to the west of the area of the nest between 20 October 1997 and 30 June 1998. The minimum foraging area of the study pair can seemingly overlap, therefore, with that of pairs in adjacent areas. Aside from those areas considered part of the foraging area of the study pair, in two instances a different pair to that of the nest was recorded within the study area; on two occasions two individuals were seen feeding in the high, central area of the BPCB. During the study of the 1997 nest, the BPCB and adjacent areas contained at least two pairs and one chick.

4.8 Population estimate in the study area

The minimum number of macaws in the study site was one or two pairs and one chick. Nevertheless, the area did not support this population all the time, but seasonally. The nest pair was present consistently for the duration of the incubation and the feeding of the chick in the nest. Subsequently it was noted that the pair would leave the study site for periods of up to two or three days. Three individuals were ultimately seen in the area, which could possibly pertain to the same pair and young bird that had been stu-

died. The visiting pair was recorded sporadically within the study area at least during the monitoring of the nest. In past rainy seasons (winter), the study site has apparently been visited by groups of up to six to eight individuals (the data concerning groups of macaws in winter is based on anecdotal information provided by local residents and wardens of the BPCB). The coincidence and repetition of the data would seem to confirm the accuracy of this information. The existence of the formation of small groups is known in this species (RIDGELY 1981, HILTY & BROWN 1986, STILES et al. 1989, JUNIPER & PARR 1998) but there is no indication as to whether this information is seasonal or post-reproductive. Prior to this study, the records of numbers of individuals in different parts of the BPCB did not exceed four (BERG & HORSTMAN 1996, HORSTMAN 1996, LÓPEZ-LANÚS 1996, POPLE et al. 1997a and 1997b); although WAUGH (1995) cites nine or perhaps more as a possible number of individuals for the entire BPCB. Outside the BPCB and adjacent areas the only nearby record of the species was some 30 km to the west at Hacienda Gonzalez (recently acquired by the National Cement Company to create a reserve). The record was of five individuals flying together in November, where POPLE et al. (1997a) had found it for the first time in July 1996.

5 Discussion

The choice of isolated *C. platanifolia* with little foliage for nest sites seems to be consistent. In addition to the nests mentioned in the results and in the case of the 1994 nest (WAUGH 1995, BERG & HORSTMAN 1996a and 1996b), other nests or potential nests discovered in the region (TORAL 1992, LÓPEZ-LANÚS 1996, POPLE et al. 1997a and 1997b) were similar in that they were chosen in isolated trees that were bare or partially bare. This particularity could be attributed to the ease of entry and exit to and from the nest without foliage and branches to obstruct them and/or for enjoying optimum visibility. Another advantage would seem to be the impossibility of entry for terrestrial predators due to the foliage of adjacent trees. Additionally, the smooth bark and the columnar shape of the trunks would make access more difficult for predators from the ground. BJORK & POWELL (1995) describe nests of the same species in Costa Rica. There, they note that chosen trees were large in size with natural cavities in the higher part, just like those known for the species in the study area. Similarly, they report the selection of isolated trees, although each of these had an adjoining tree and foliage near the nest hole which they entered. With respect to the dimensions of the nest hole, LÓPEZ-LANÚS (1996) measured the nest discovered in BPCB in 1994 (WAUGH 1995, BERG & HORSTMAN 1996, HORSTMAN 1996a and 1996b), recording the following dimensions: height of the lower part of the entrance to the floor of the chamber = 350 mm, diameter of the chamber = 410–540 mm, estimate of the diameter of the entrance = 500 mm, minimum estimate of the height of the chamber = 620 mm. This chamber was totally spherical with a side entrance, while that of 1997 was open from above. Whilst measurements were not taken of the 1997 chamber, the internal dimensions seemed similar. This estimate is possible given the observation of the distance that the female's tail extended outside the hole during incubation or the flapping of the wings of the chick when it was learning to fly from the lower part of the

chamber; such cases did not indicate a greater depth of cavity compared to the 1994 nest. This data is of great importance in the construction of artificial nests to avoid uncertain dimensions and proportions.

In terms of feeding, the diet and the actual daily percentages recorded must differ from the data analysed in the current study. Such a conclusion can be drawn on the basis of the impossibility of following the species continuously throughout the entire study period. Similarly, the impossibility of observing in every instance which of the two orchid species the birds were eating means that the percentages of preference for one or the species are speculative. However, the analysis does indicate a tendency in the feeding preferences. The change in feeding preferences noted in Table 2a-d would seem to be due to the flowering or fruiting of certain species, as was the case with *C. platanifolia*, thus varying the seasonal availability of the diet. The consumption of orchids was common throughout the study period (Table 2a-d), although there was seemingly no other food of a similar nature to the orchids with which to make a useful comparison. The greatest ingestion of seeds of *C. ochroxylum* could be related to the onset of the rainy season causing the fruits to soften when they are wet, therefore allowing easier access to the seeds. The consumption of bark or powdered bark of *C. platanifolia* was part of the diet of this species. Speculatively, the possibility exists that this bark could supplement the ingestion of clay and/or dry rotten wood which other species of the genus use as detoxicants (see MUNN 1992 and 1994). To this end its chemical components and traces of metals were analysed as data comparison for future, more detailed studies.

In the case of the attacks by *A. nitida*, it could not be determined whether they were territorial or predatory. The fact that the attacks only took place when the male macaw was present would indicate territorial behaviour; in addition, an attack never took place on the eggs, nor when the chick was left alone in the nest by its parents. In general terms, in the area of study the species showed behavioural traits already known for the genus and Ara ambigua. Comparing the number of daily sorties from the nest by the parents between the 1994 and 1997 nests, there is an important difference in terms of the amount of time spent in absence from the nest, at least 42 days prior to the abandoning of the nest by the offspring. Nevertheless, in the 1994 nest, the behaviour of the parents prior to this time was unknown, and it cannot be confirmed that the pattern of behaviour was the same all the time. Very probably the difference between a more protected nest (like the 1994 nest) and a less protected one (like the 1997 nest) alters the frequency of absence of the parents. Another factor which could alter this sequence is the distance covered to find food. Comparing the number of visits recorded by BJORK & POWELL (1995) in nests in Costa Rica, the pair of the 1994 nest was absent for similar periods of time (two to three hours) but making fewer daily sorties (four to six, according to the work cited, compared to three or four in the 1994 nest). In the case of the 1997 nest, this pattern must have been changed to fewer sorties through the pressure from predators in the area of the nest. Records of reproduction of the species in Central America (BJORK & POWELL 1995, COLLAR 1997) correspond to the dry season, like the region of the present study but with the seasons reversed. With reference to the use of branches adjacent to the nest chamber by the chicks before being able to

fly (BJORK & POWELL 1997), in the 1994 nest the few branches next to the nest did not turn out to be important for the development of its physical flight condition.

The record of a nest taken by *M. semitorquatus* suggests the existence of competitors in the use of natural cavities for nesting. The breeding success of the 1997 nest would have been annulled if it had not been for human intervention. *M. semitorquatus* is not rare in the BPCB and surrounding areas (LÓPEZ-LANÚS, in prep.), which suggests that the population of *Ara ambigua* in the area and the region in general could come into competition with this species through a lack of nest sites. Another limiting factor as regards the availability of natural cavities for nesting is the short duration that dry *C. platanifolia* remain standing. Many inhabitants in the study zone commented that within three or four years this species of tree, once it has withered, is eaten by termites and then falls to the ground with the advent of the summer winds or the softening of the soil during the rainy season. This fact is also recorded in BERG & HORSTMAN (1996) and HORSTMAN (1996). The decrease of remnant forest patches in the Cordillera Chongón-Colonche is in direct proportion to the increase in the production of livestock farming and of coal (PARKER & CARR 1992, BERG 1994, WAUGH 1995, BERG & HORSTMAN 1996, HORSTMAN 1996, LÓPEZ-LANÚS, pers. obs.), thus eliminating a greater number of natural cavities for nesting and the renovation of *C. platanifolia* forests. As an additional factor, the „harvesting" of chicks in the region is from old data. P. YAGUAL (pers. comm.) remembers having found in areas adjacent to the study site a *C. platanifolia* where a system of bamboo scaffolding had been constructed to extract chicks of this species. Similarly, TORAL (1992) recorded the „harvesting" of chicks and/or their sale in retail outlets located in the city of Guayaquil, and the acquisition of this species as a pet continues today (LÓPEZ-LANÚS, pers. obs.) Such factors are of utmost importance in making decisions to avoid the extinction of the species.

The fact that the parents of both the 1994 and 1997 nests depart from and arrive in the area of the nest from differing directions reaffirms the suggestion of BJORK & POWELL (1995) in that such behaviour is down to the fact that the species changes its feeding areas. The comment that during the first few days, the chick was clumsy when landing cannot be affirmed as a typical event in this species given that it began to fly under unnatural conditions and perhaps prematurely. The chicks of the 1994 nest were not seen landing as they flew a long way from the nest on their first flight, therefore no data exists on this. In Costa Rica, BJORK & POWELL (1995) used radio tracking in young birds of this species, thus determining the pattern of movements of the young after they had abandoned the nest. The records of the chick observed in 1997 correspond with the same pattern of behaviour, at least during the first three weeks of monitoring after it began to fly.

6 Conclusion and recommendations

Within the BPCB and adjacent areas the species has food and suitable sites for reproduction. The forests of *C. platanifolia* seem to be of extreme importance for the spe-

cies in this area. The provide cavities for nesting, shelter to spend the night, food and part of the main diet of the species. Whilst the exact size of the foraging area of the pairs during the breeding season (summer) is not known, it seems to be up to at least c. 2,000 ha. In the rainy season the area seems to contain groups of up to eight individuals. Given the presence of competitors in the usage of nesting cavities, the best way

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of inducing breeding in the area would seem to be through the use of artificial nests. However, ecological studies of the species must continue on a permanent basis and for the period of a year in order to know exactly if each breeding pair needs to have a minimum area for its territory to satisfy the needs of feeding and the offspring. This is important to avoid a potential imbalance, harming the natural density of the species' population. As regards using artificial nests, the suggestion is to locate them in *C. platanifolia* that are isolated and largely devoid of foliage in the tree crown. The artificial cavity will need to have at least the dimensions cited in „Discussion" in this report. It could be located in the upper half of the chosen tree, no less than eight metres in height in accordance with the records presented in „Results" and „Discussion". The tree will need to be chosen not only for its own condition but also by studying the condition of the surrounding area. The use of radio tracking is advisable with the intention of knowing the extent of movements of the species.

Due to prolonged absences of the breeding pair outside the protected area it is advisable to negotiate funds to acquire land to protect a greater area of favourable habitat for

the species. In terms of acquiring areas with pasture or degraded secondary forest it is advisable to reforest these areas with native species, including those recorded as forming part of the species' diet. It is essential to continue the program of environmental education of the Fundacion Pro-Bosque with the intention of informing people living adjacent to the BPCB and the area in general about the need to conserve the species and not destroy its remaining habitat. The low number of individuals recorded in the study area and the fact that sorties to search for food were spent outside the protected zone over a large area underlines the need to formulate a conservation plan for the species throughout the region (i.e. Cordillera Chongón-Colonche) and not only in the area of study. On the other hand, the removal of the Guayaquil airport to the outskirts of the city of Chongón (about 5 km from the BPCB) would undoubtedly cause noise pollution in the species' habitat. Therefore studies regarding the environmental impact of this development are recommended.

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